Prof. Mel Ulmer

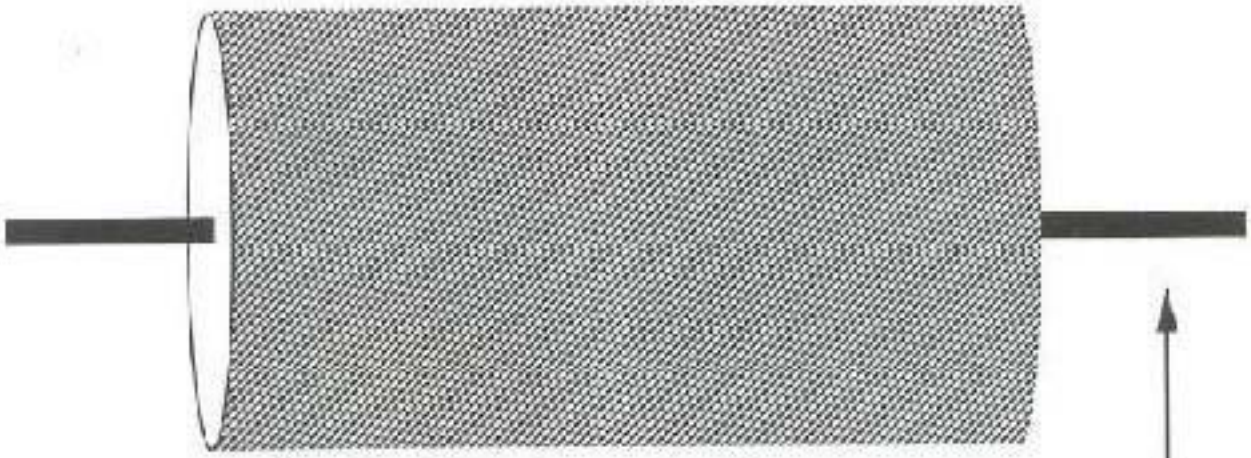
DEPT OF PHYSICS

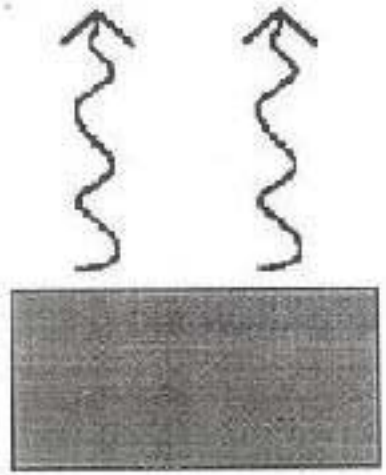
&

ASTRONOMY

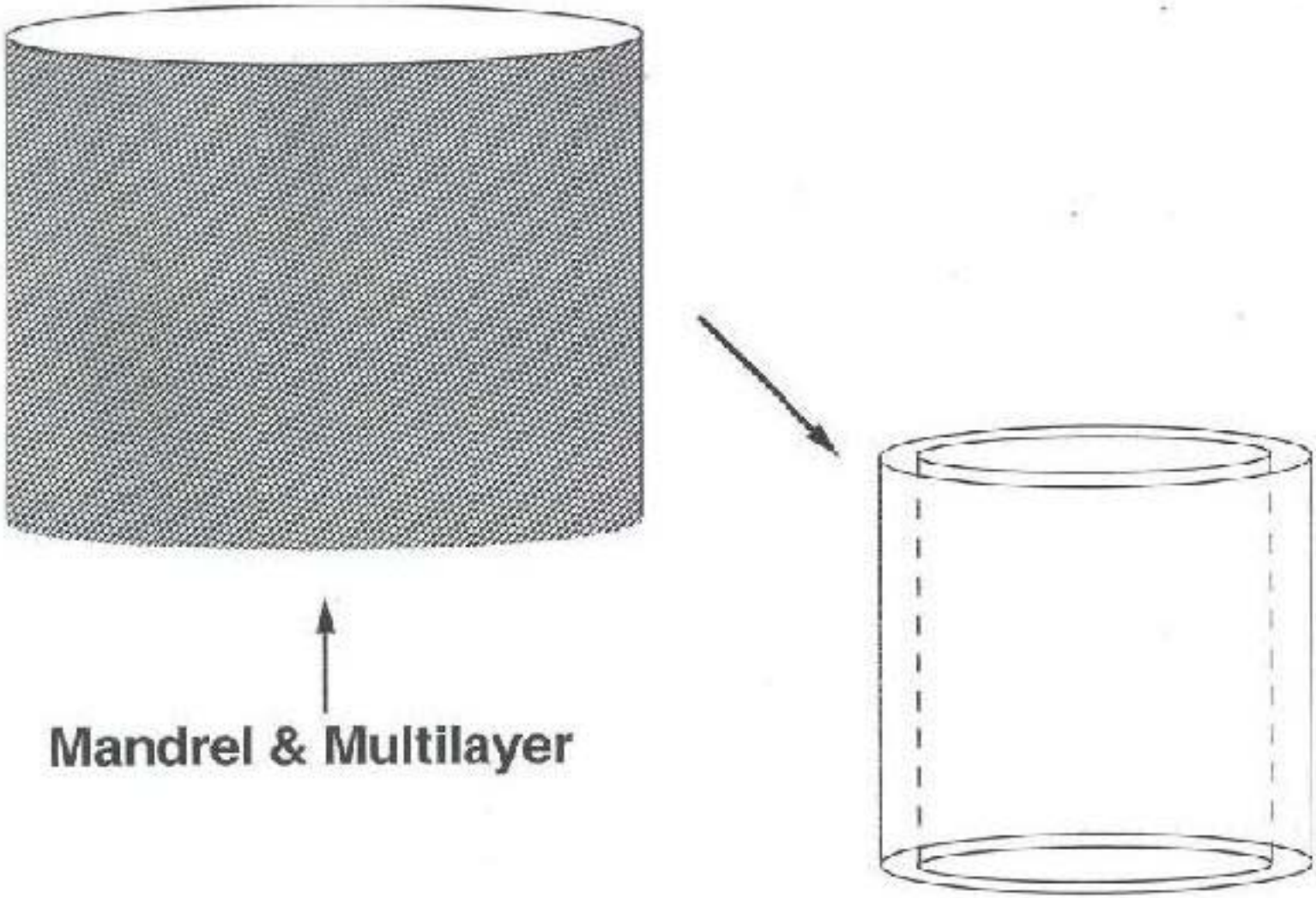
The Concept:

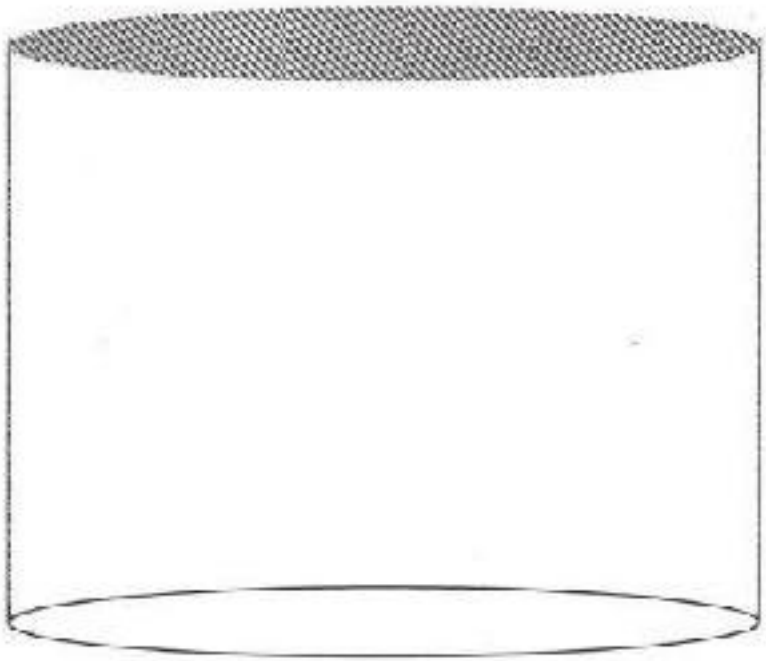
Intact Electroforming Multilayer Process

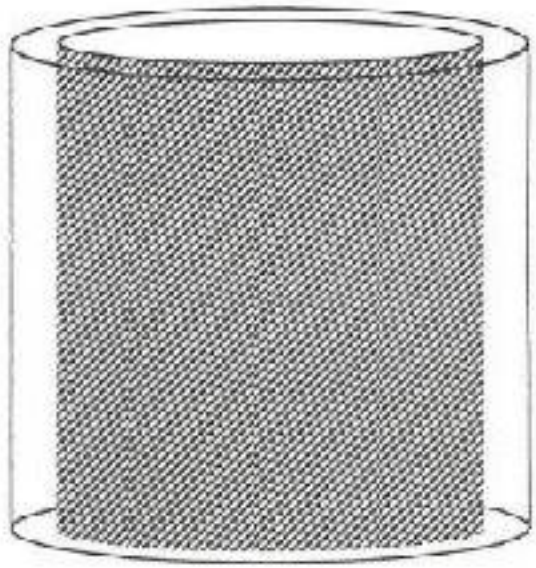




Sputtering Gun

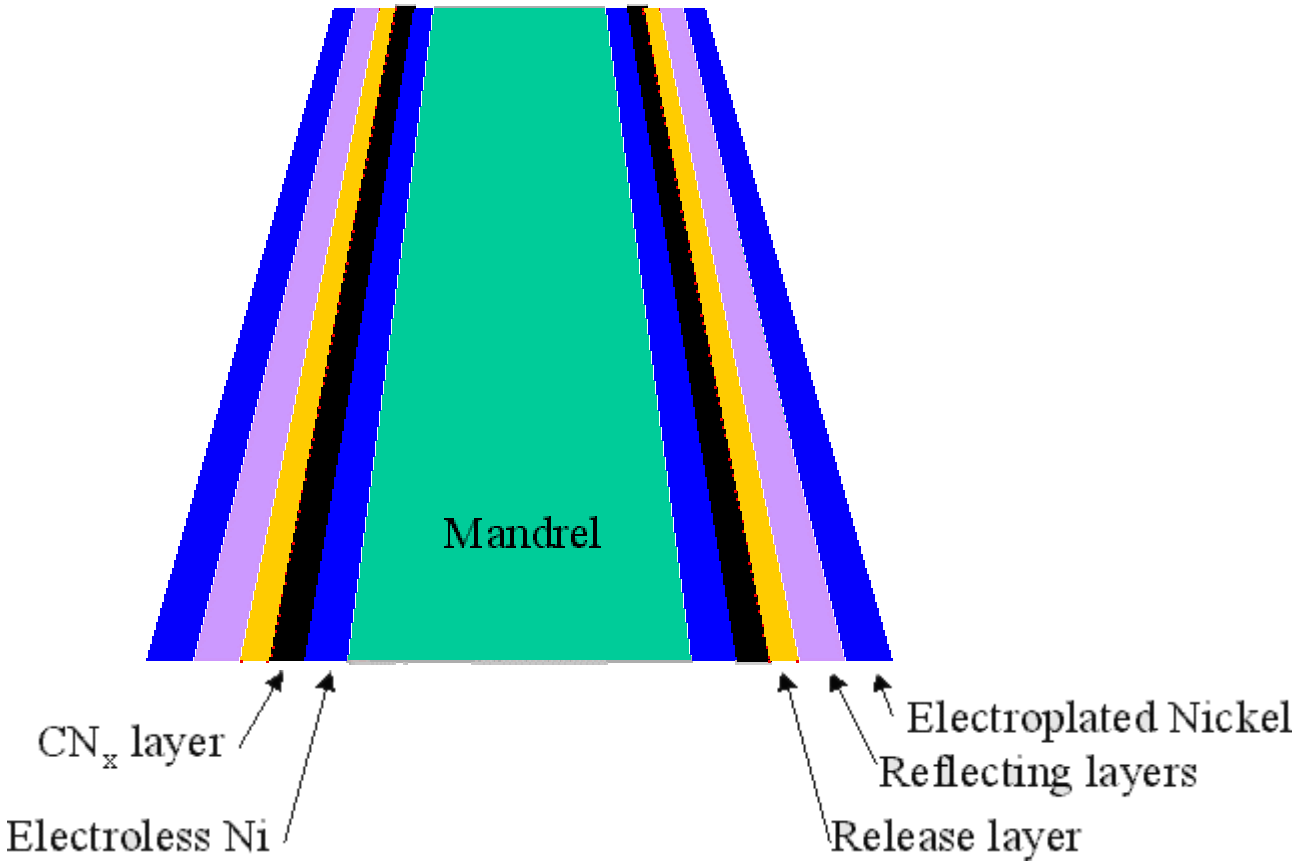

Mandrel & Multilayer
Mandrel with electrodeposited nickel





Removed Electroform.
Multilayers on inside.

Coated Mandrel

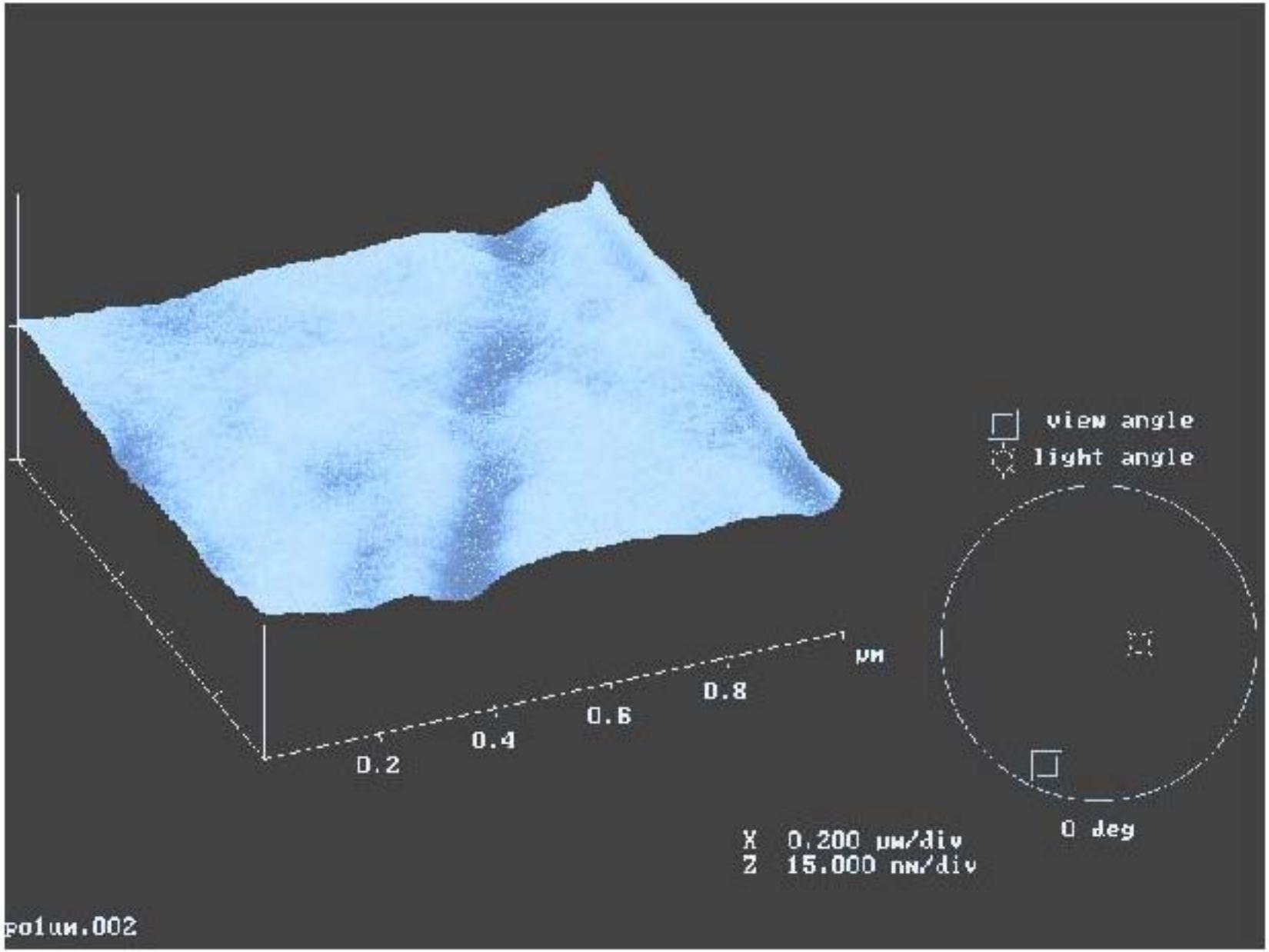


Advantages of IEMP:

- Coat Mandrel => Focal Length, small as 1-2 meters => SMEX is possible

- Electroforming offers the best angular resolution (< 10 arc sec) outside custom figuring

- An additional advantage of proccess at NU = CNx coating (10 nm) smooths & protects


view angle
light angle
μm
0.2
0.4
0.6
0.8
0 deg
X 0.200 μm/div
Z 15.000 nm/div
polun.002

Now the entire process:

Coat mandrel with CNx

Coat mandrel with release layer

Coat with multilayers

Coat with adhesion layers

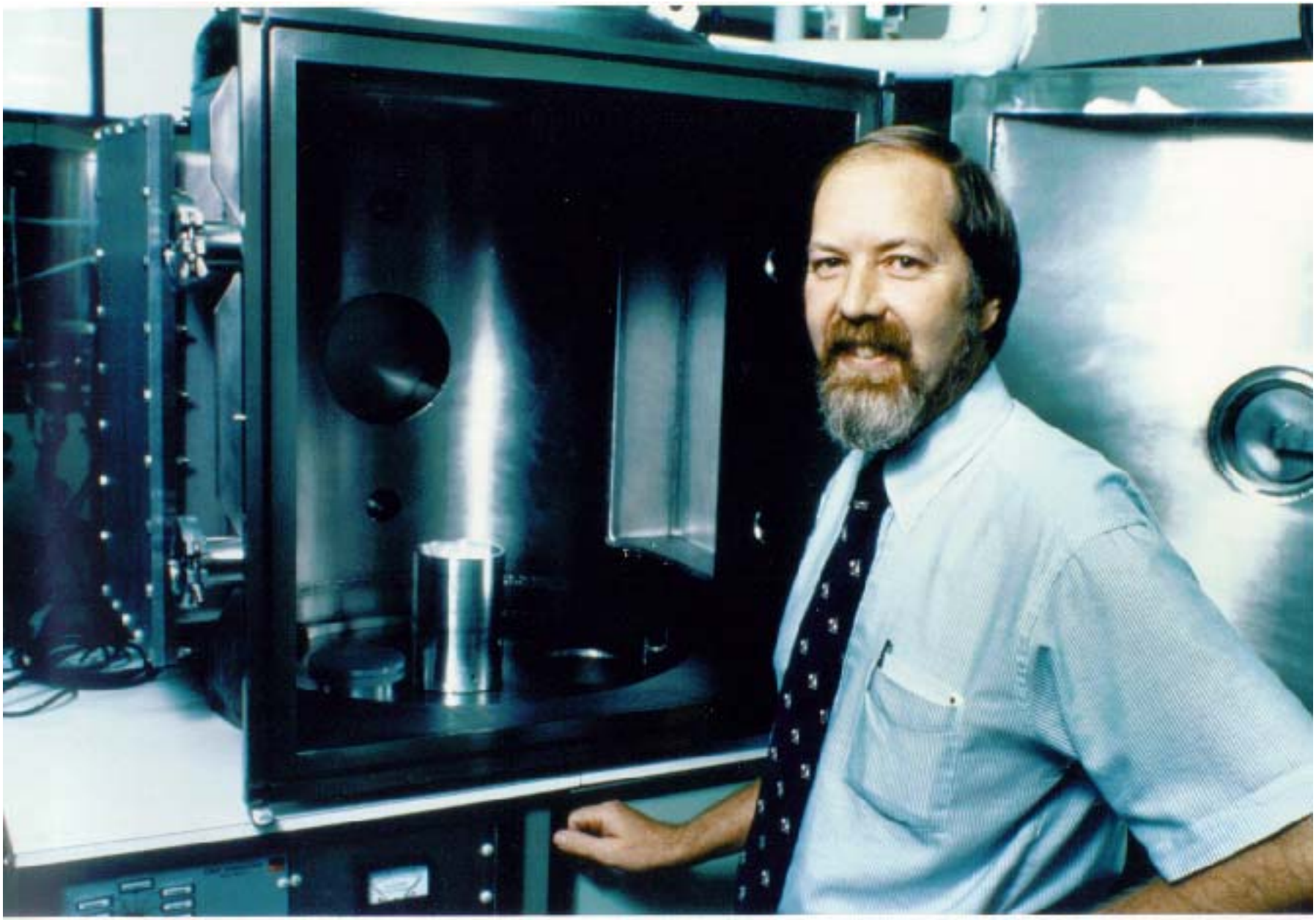
Electroform

Remove electroform

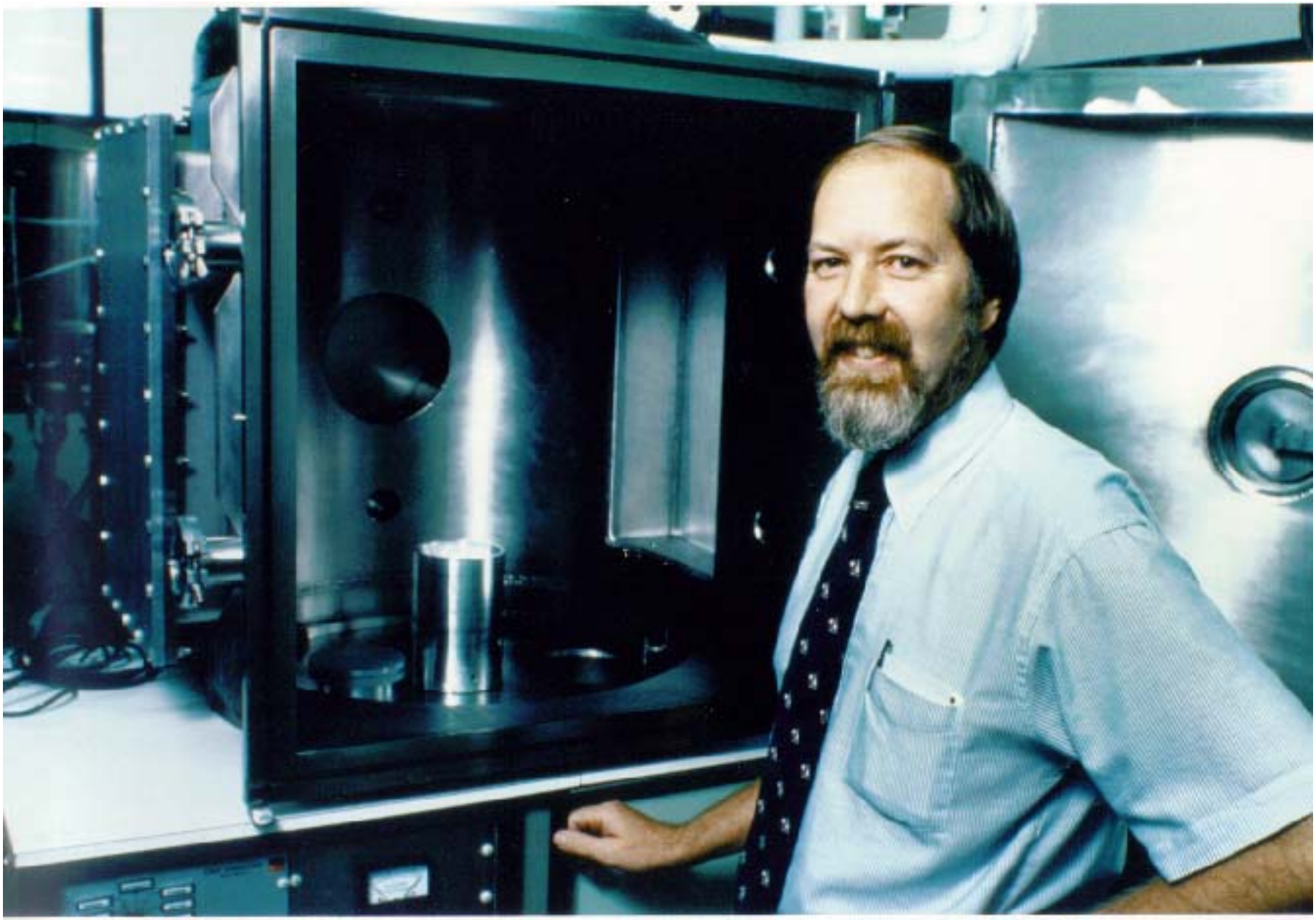
Remove release layer

Therefore, Total Institutional Integration is

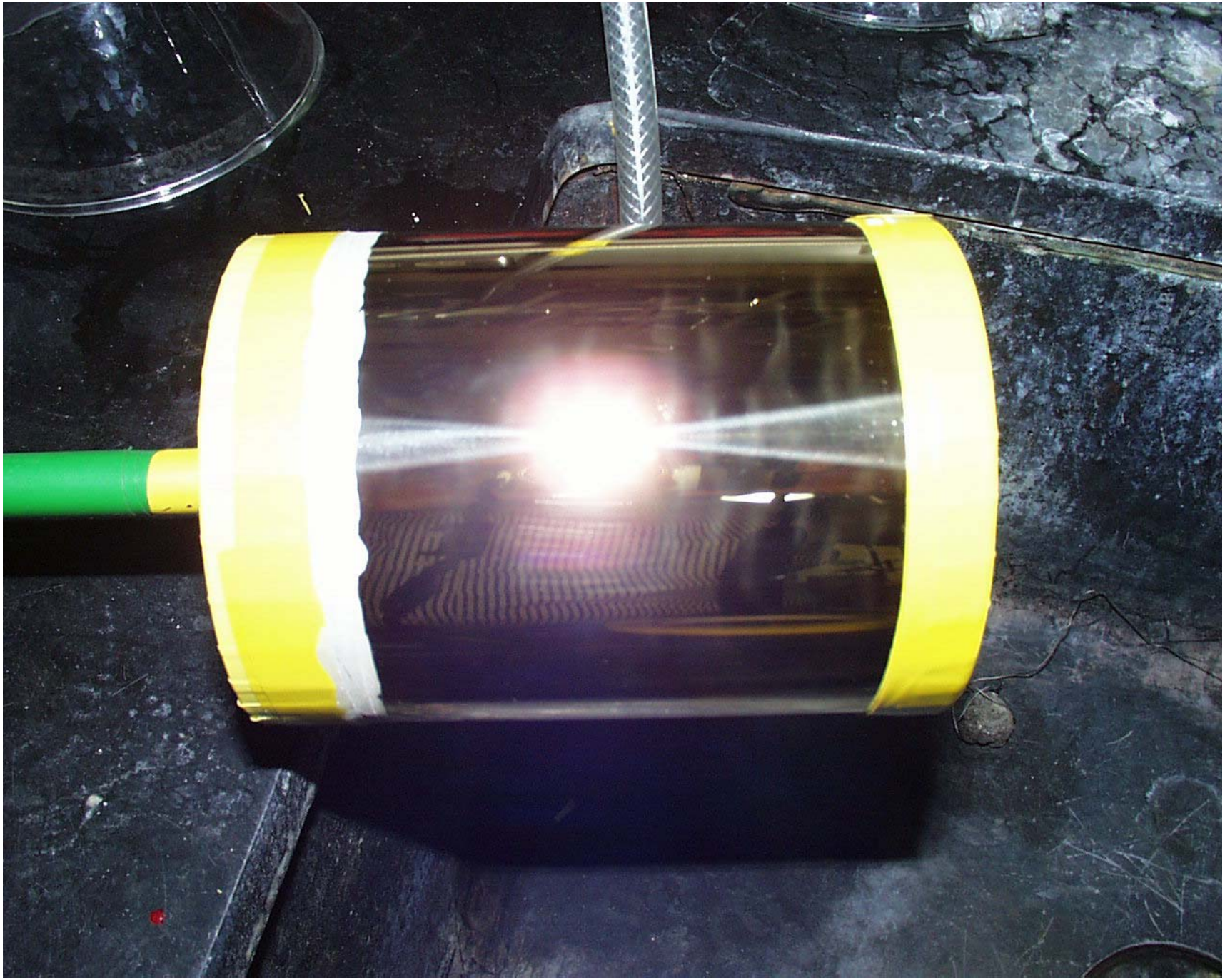
VERY IMPORTANT

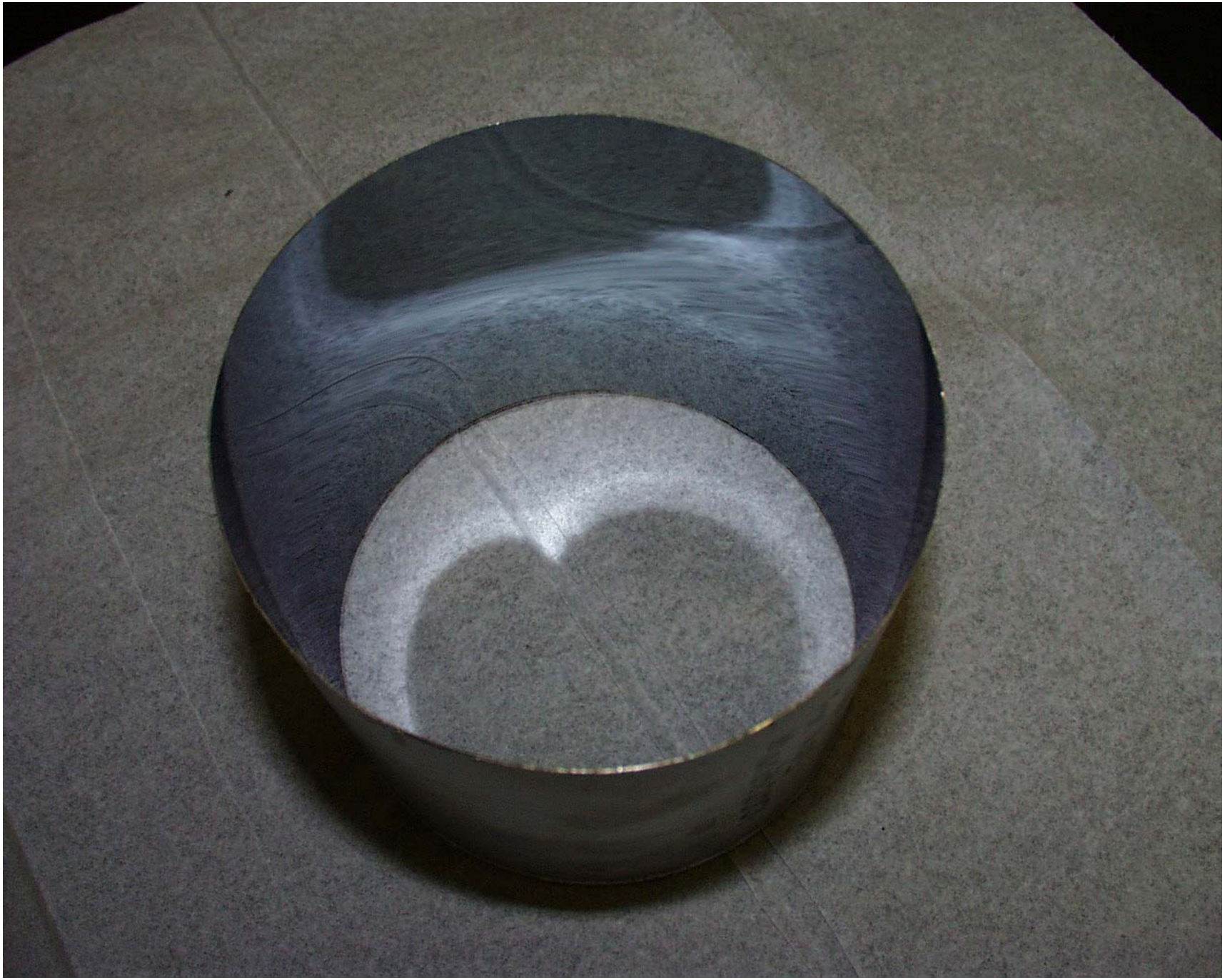


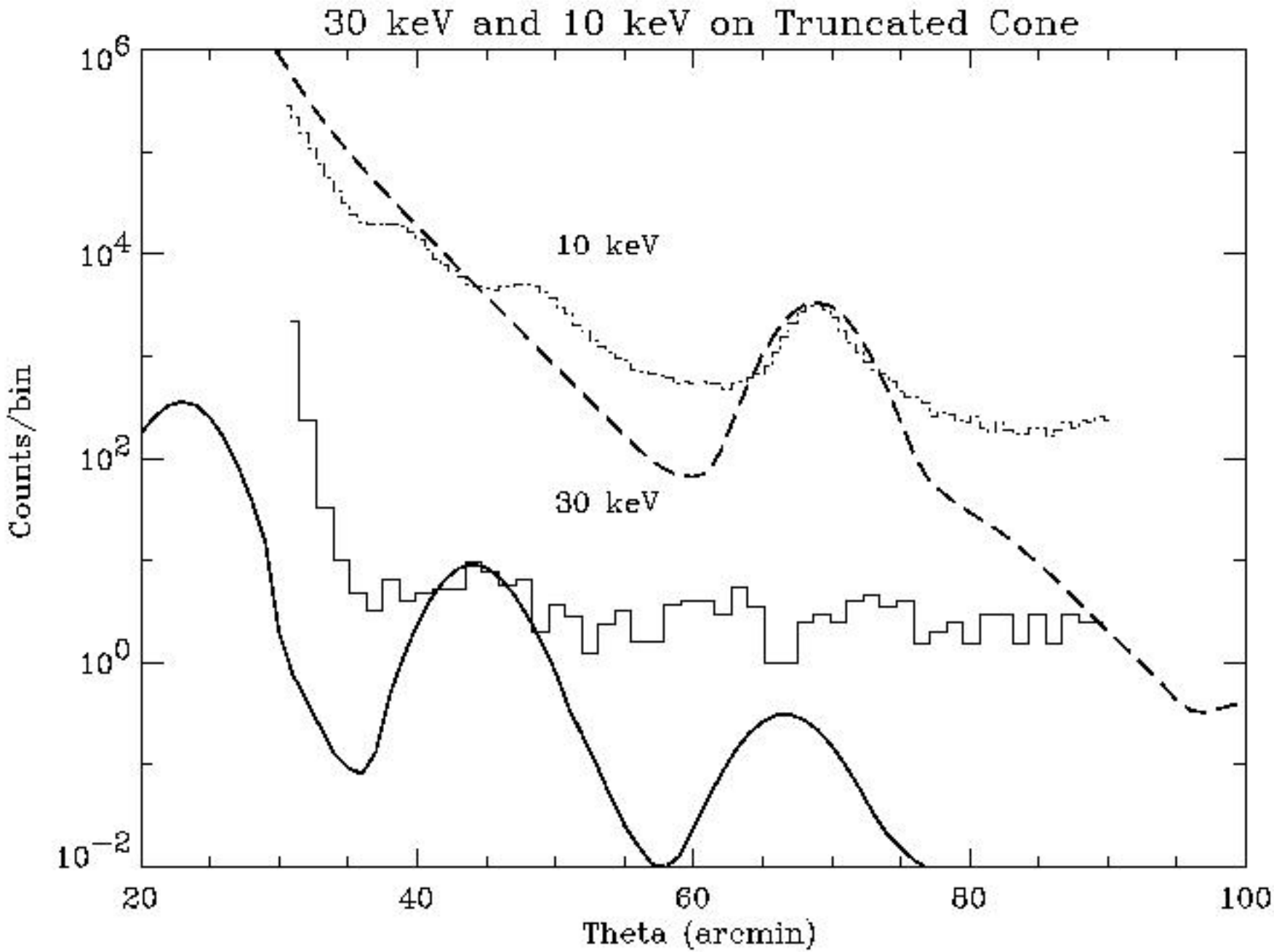

WAST

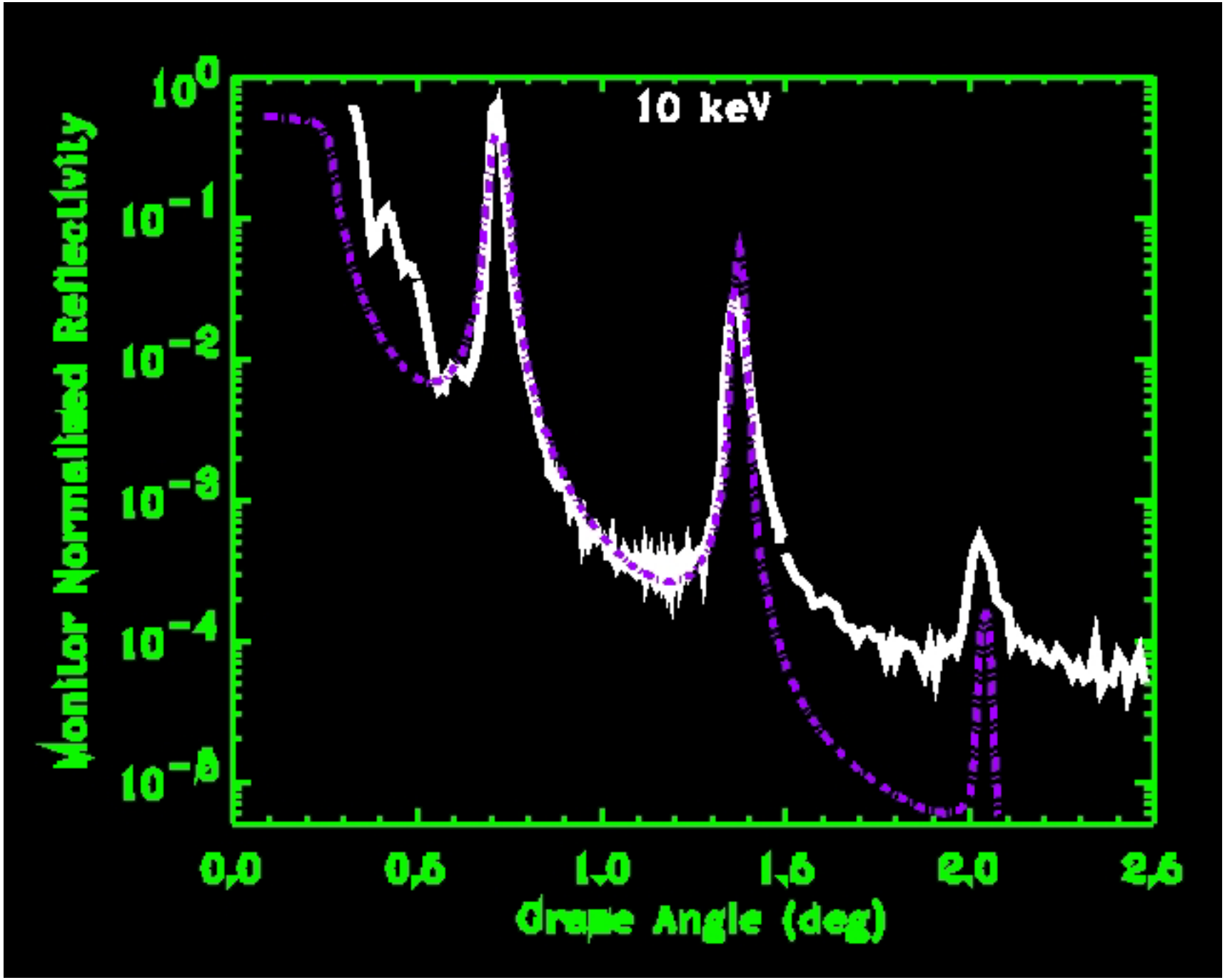


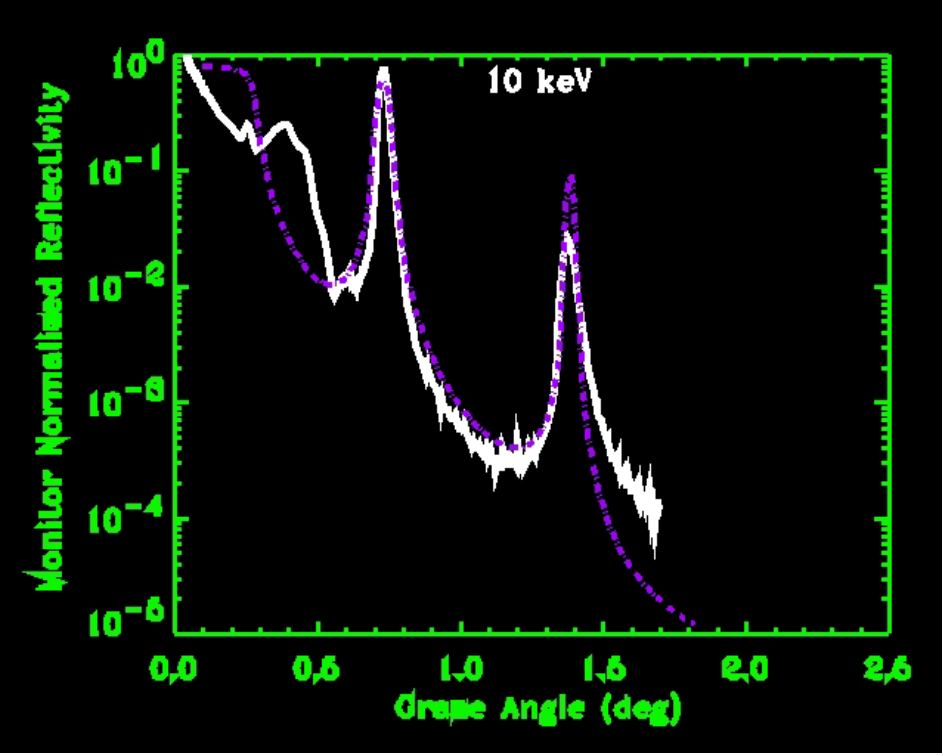

WAST





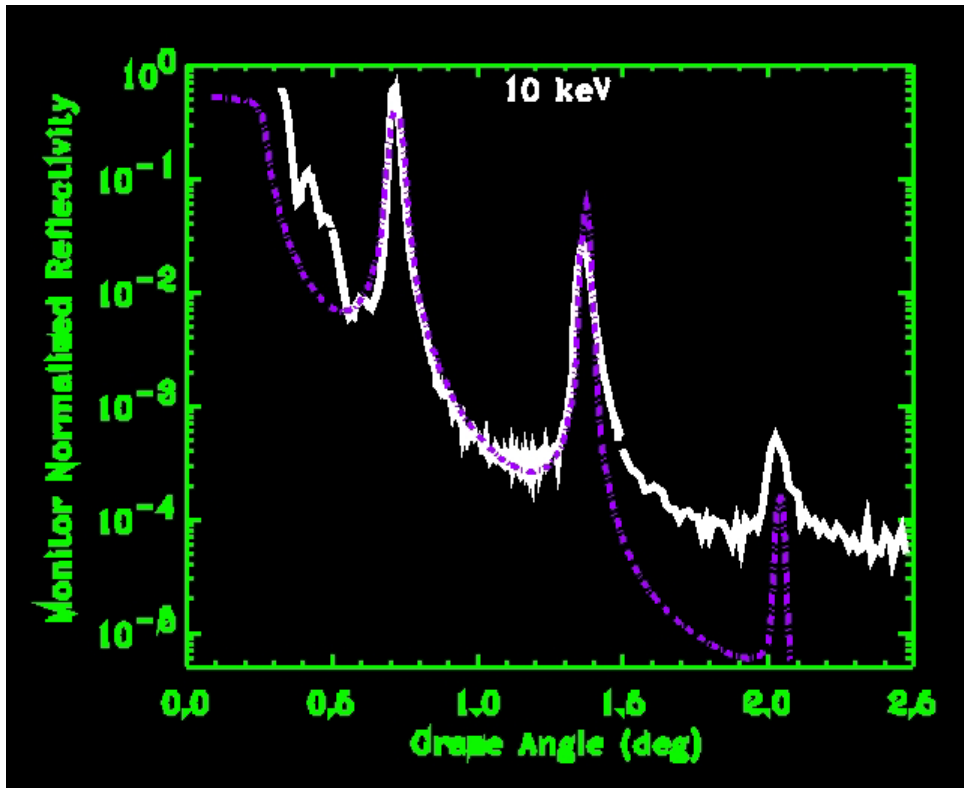

30 keV and 10 keV on Truncated Cone
10 keV
30 keV
Counts/bin
Theta (arcmin)
10^6
10^4
10^2
10^0
10^{-2}
20
40
60
80
100


10 keV
Monitor Normalized Reflectivity
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0.0
0.5
1.0
1.5
2.0
2.5
Grazing Angle (deg)

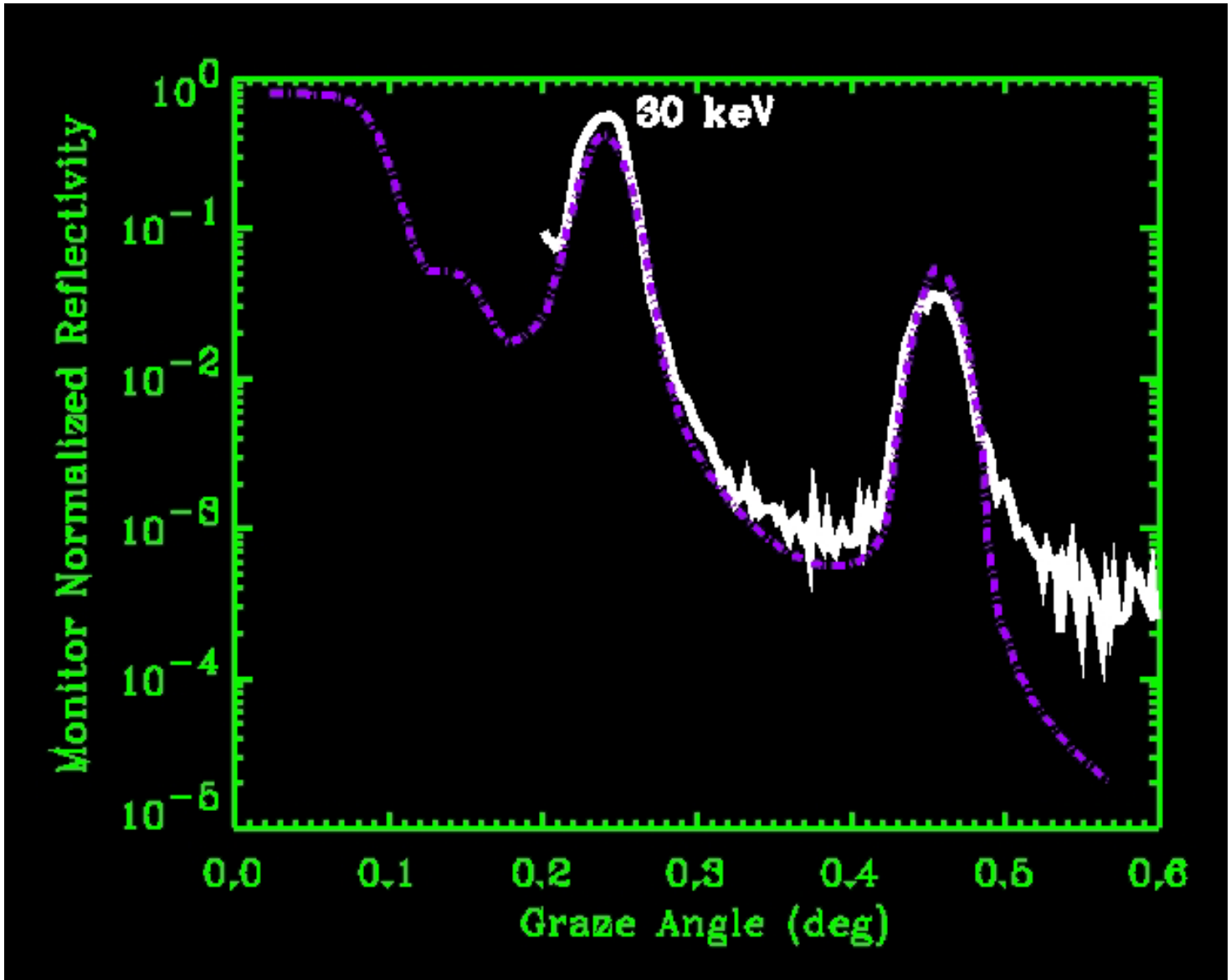


Two different orientations about optical axis, same energy; W/Si 5.29 nm

About 90 deg rotation



Higher Energy



Follow Up & Evaluation:

Correction for Geometrical Effects at 10 keV:

Evaluated a 1 cm segment, derived 17 % reflectivity

At first Bragg peak

Optical trace of 1 cm segment verified geo. corr.

Si “witness sample” 16% reflectivity

More Optical Evaluation:

Mandrel pre- CNx coating

Roughness 1.1-3.2 nm

Mirror Segment Roughness 0.5-0.6 nm!

Agrees with fit to X-ray data

Conclusion: Excellent Multilayers because:

- Same Bragg angles at different energies, more penetrating versus less
- Narrow Bragg peaks
- One multilayer d-spacing = 5.29 nm fits all
- Same Bragg angles at different axis rotations
- All the data point towards 14-20% reflectivity

Overall conclusions

- We can put viable multilayers on the inside of mirrors!

- The entire process:
  - CNx plus IEMP are a success
  - For high quality optics
  - flexibility in design, IEMP is it.
- The only problem may be mass

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Helpers, collaborators, etc. : Al Krieger, Dan Parsignault, Derrick Mancini, Matt Steele, Megan Krejny, Peter Takacs, Yip-Wah Chung, Jane Chang

NASA Support: SR&T and
Con X

www.astro.nwu.edu/astro/faculty/ulmer

Where would we like to go from here?

Progress to new chamber with graded d-spacing

Coat our much better Zeiss Mandrel

Then replicate success on a Wolter I

Test MSFC

Then?? A SMEX path finder? A Midex Survey or ??

The

End